Global climate change and the water cycle

Global warming is driving changes of extreme weather that will have impacts on food security, human and animal health, energy supply and water resources. Adaptation strategies are urgently needed not only to adjust to these new conditions, but also to meet the needs of the growing world population in this increasingly challenging environment.

How does the interaction between water and energy affect our weather?

The tropics receive the most sunshine and this heat energy is continually distributed to the polar regions, from where it escapes back to space. Transported via ocean currents and by global atmospheric circulation, this movement and exchange of energy is intrinsically linked to the hydrological cycle (see Figure 1). As the atmosphere warms, a vapour pressure deficit is formed, and surface moisture evaporates and is transferred to the atmosphere through convection. This evaporated moisture is energy stored in the atmosphere as latent heat. When the water vapour condenses to rainfall, the heat is released and energy radiates back to space. This process of mass transport of air, moisture and energy creates the climate system that results in our day-to-day weather.

More extreme weather patterns, thanks to greenhouse gases

The increase in the atmospheric concentrations of greenhouse gases (GHGs) is causing the atmosphere to retain more energy, raising its temperature and increasing its capacity for holding water—and its rate of transfer and release of this entity—causing our climate systems and weather patterns to change.

The Earth's climate system responds to this by establishing a new equilibrium, through increasing the speed at which the energy is circulated and released. The higher temperatures resulting from the GHGs increases evaporation, and the higher quantities of water vapour in the atmosphere lead to increased precipitation as it condenses. Such "speeding up" is experienced as a more variable and extreme climate. Rain will fall in shorter, more intense bursts and the dry periods between rainfalls will get longer (Trenberth *et al.*, 2003). These effects are already evident in the Southern African rainfall data (Kruger, 2006; New *et al.*, 2006). This increase in rainfall is regionalised. Generally, wet tropics will get wetter while the dry tropics may become wetter or dryer. River flows are likely to increase in the wet tropics and at high latitudes above 50°N (Bates *et al.*, 2008).

The increase of GHGs in the atmosphere will result in shorter, more intense bursts of rain, followed by longer dry periods.

Impact on agricultural productivity and food security

When soils remain dryer for longer, surface temperatures rise because less solar energy can be partitioned into latent heat. Growing conditions for crops will become more difficult as a result of higher temperatures and fewer but more intense rainfalls. Soils will become hotter and more prone to soil crusting, drying and erosion leading to greater surface runoff and loss of soil carbon, making the soil less fertile and less able to hold moisture.

Sub-tropical regions will become more arid and pre-disposed to vegetation loss, with lower rates of biomass production. Droughts have already become more common in subtropical regions since the 1970s (Kundzewicz *et al.*, 2007; Bates *et al.*, 2008;).

Combined, these conditions will negatively affect agricultural productivity and food security.

Adapting to these changes

Adaptation is needed to cope with these changes. Provision must be made to store more water, especially in the subtropics, and to manage it better during the longer dry periods. Infiltration should be encouraged in agricultural practices through better soil surface cover (mulching), to help reduce terrestrial surface temperatures and reduce plant stress.

The maxim that "available water is either too much, too little or too dirty" will become even more relevant. Management practices will need to accommodate the new, evolving conditions.

Improved water-use efficiency, water management and reuse offer "no-regret" options for early adaptation (Kundzewicz *et al.*, 2007) and better integration of water resource demands should also create a trend towards greater sustainability. These and other adaptive strategies are needed to minimise negative impacts on sectors important to human welfare, including food security, human and animal health and energy.

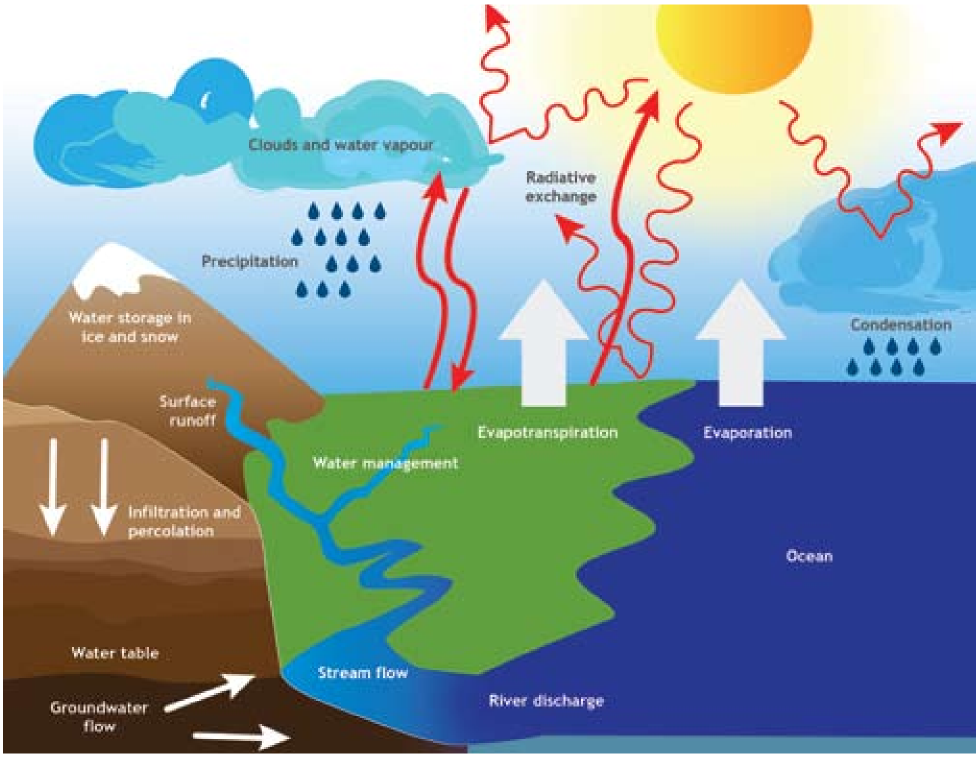

Figure 1. The hydrological (water) cycle

CASE STUDY:
In Southern Africa, water resource managers need to improve water management practices to cope with the increasing variability of the climate, the change of which is already observable.

GLOSSARY:
hydrological (water) cycle:
the continuous movement of water on, above and below the earth.
greenhouse gases (GHGs):
gases that collect in the atmosphere and prevent heat from escaping.
global atmospheric circulation:
the large scale movement of air/atmosphere over the earth.
infiltration:
the movement of water from the surface of the ground into the soil.

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